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# Differential effects of time to initiation of therapy on disability and quality of life in patients with mild and moderate to severe ischemic stroke

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## Abstract

**Objective:** To assess the impact of time to acute therapy on health-related quality of life (HRQoL) and disability after ischemic stroke.

**Design:** Prospective cohort study

**Setting:** Comprehensive stroke care center in a large metropolitan city

**Intervention:** N/A

**Main Outcome Measures:** Disability status was assessed with the modified Rankin Scale (mRS) and Barthel Index (BI). Health-related quality of life was assessed using Neuro-QOL measures of executive function, general cognitive concerns, upper extremity dexterity, and lower extremity mobility. Time to therapy consult and treatment were defined as the number of days from hospital admission to initial consult by a therapist and number of days from hospital admission to initial treatment, respectively.

**Results:** Among the 553 participants analyzed (mean age 67 years; 51.9% male; 64.4% white; 88.8% ischemic stroke), the median number of days from hospital admission to acute therapy consult was 2 [IQR: 1–3] days. Multivariable linear and logistic regression models indicated that for those with NIHSS score <5, longer time to therapy consult was associated with worse BI scores (BI < 100: OR=0.818, p=0.008), executive function T-scores (b=−0.865, p=0.001), and general cognitive concerns T-scores (b=−0.609, p=0.009) at 1-month in adjusted analyses. In those with NIHSS score >5, longer time to therapy treatment led to increased disability (i.e., mRS>= 2:

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OR=1.15, p=0.039) and lower extremity mobility T-scores (b=−0.591, p=0.046) at 1 month in adjusted analyses.

**Conclusions:** Longer time to initiation of acute therapy has differential effects on post-stroke disability and HRQoL up to 1-month after ischemic stroke and TIA. The effect of acute therapy consult is more impactful for those with mild deficits, while the effect of acute therapy treatment is more impactful for those with moderate to severe deficits. Minimizing time to therapy consults and treatments in the acute hospital period might improve outcomes after ischemic stroke and TIA.

### Keywords

Neurological rehabilitation; acute Stroke; health services; Quality of care; patient reported outcomes

It is well established that acute therapy services (i.e., therapy services provided within medical/surgical units) are critical to recovery of function after stroke,[1–3] and clinical guidelines state that therapy services should be initiated as soon as the patient is able to tolerate it.[4,5] However, recent literature reviews indicate that there is insufficient evidence to justify the implementation of early therapy interventions,[6] and the timing of initiation of acute therapy services remains controversial.[7–9]

Generally, the long-term impact of therapy services is examined through global measures of impairment and disability (e.g., Barthel Index, modified Rankin Scale: mRS).[10,11] These measures are widely used and have been incorporated in research studies and clinical practice, both as measures of patient recovery and as quality indicators.[12,13] Although informative, these measures do not integrate the patients' perceptions of their own recovery.[12] Recent advancements in symptom and health status assessment have enabled valid and reliable measurement of multiple health domains from the patient perspective using patient-reported outcomes (PROs).[14–16] Despite criticism that PROs are not objective measures of patient function, to date, PRO's used in stroke research have shown strong correlations with traditional clinician-assessed measures of impairment, such as the Barthel Index and the mRS.[12,17–19] However, PROs have been shown to provide more granular information in terms of distinct types of dysfunction and symptoms. Moreover, PROs have been shown to be better at detecting impairments in those with the milder strokes, where traditional measures fail to detect impairments; as such, PROs may serve as early indicators of impairments.[20,21] Several studies suggest that up to one quarter of patients classified with no disability with the mRS, specifically noted physical and cognitive impairments through simultaneously administered PROs.[12,18,20–23] Others have argued that PROs may be used to identify the context in which impairments are more noticeable for patients (e.g., reading vs. learning new tasks).[19] Despite these potential advantages, to our knowledge, no studies have assessed the impact of time to initiation of acute stroke therapy services on post-stroke outcomes using PROs. The purpose of this study is to assess the impact of time to initiation of acute therapy on patient reported quality of life.

# Methods

## Participants

A total of 764 adults admitted to a large urban stroke center from August 2012 to January 2014 with ischemic stroke or transient ischemic attack (TIA) were enrolled in a longitudinal observational study of post-stroke outcomes. Patients or their legally authorized representatives provided informed consent. The requirement to consent was waived by the Institutional Review Board when patients could not be consented (e.g., due to coma) or when the legally authorized representative could not be located. Demographic and clinical data, including risk factors, stroke severity using the National Institutes of Health Stroke Scale (NIHSS)[24], stroke subtype using the Trial of Org 10172 in Acute Stroke Treatment (TOAST) classification[25,26], comorbidities, and in-hospital complications were prospectively captured by a team of vascular neurologists and research coordinators.[17,18] For those who received therapy services (n=559), the types of therapy services (i.e., physical therapy, occupational therapy, and speech and language pathology), dates of therapy consults, and dates of therapy treatments (i.e., visits after initial consult) were retrieved from the institution's Enterprise Data Warehouse, an integrated database of electronic health-records. To mitigate potential bias from statistical outliers, a total of 6 participants were excluded who left the hospital against medical advice, died within one day of admission, or whose length of stay (LOS) was less than one or more than 30 days. A total of 553 participants comprise the analytic cohort.

## Measures

Time to therapy consult was defined as the number of days from hospital admission to initial consult by a therapist. Likewise, time to initiation of therapy treatment was defined as the number of days between hospital admission and the first therapy treatment. Disability status was assessed through a standardized telephone interview[27] using the mRS, a post-stroke outcome measure of disability with scores that range from 0 (no symptoms) to 6 (dead).[28] The Barthel Index (BI) was also used as a measure of an individual's ability to care for him or herself. This is a valid and reliable 10-item scale with scores ranging from 0 (dependent) to 100 (independent).[29,30] Preliminary data inspection indicated a strong correlation between mRS and BI scores ($rho = -0.86$, n=264), so the requirement to collect BI was dropped from the data collection protocol to help mitigate response burden and attrition at follow-up. Health-related quality of life was assessed using Neuro-QOL measures of executive function, general cognitive concerns, upper extremity dexterity, and lower extremity mobility. Neuro-QoL measures of Upper Extremity Dexterity (UED) and Lower Extremity Mobility (LEM) were used to assess health-related quality of life related to physical function. The Neuro-QoL measure of Applied Cognition-Executive Function (EF) assessed perceived difficulties in applications of mental functions related to planning, organizing, calculating, etc., and the Neuro-QoL measure of Applied-Cognition-General Cognitive Concerns (GCC) assessed perceived difficulties in everyday cognitive abilities, like memory, attention, and decision making.[31] Scores from Neuro-QOL measures are centered on the estimated U.S. general population mean of 50 (or in select cases, the mean of a clinical sample) with a standard deviation of 10, with higher scores indicating more of the assessed symptom or trait. Substantial validity and reliability evidence support the use of NeuroQOL[15,16,32–35].

## Statistical analysis

**Impact of time to therapy on patient outcomes—**A series of linear regression models estimated the association between time to therapy services and patient outcomes at 30 days post-stroke, including disability (i.e., mRS and BI) and self-reported quality of life (i.e., NeuroQOL) that controlled for age, stroke severity, and stroke subtype. Based on previous findings indicating that NIHSS ≤5 was an optimal cutoff for mild strokes and predicts favorable post-stroke outcome[36–38], the sample was stratified by NIHSS score to investigate potential differential effects of acute therapy on 30-day outcomes by categories of stroke severity. While residual errors from these models were sufficiently normal to proceed with interpretation, scatterplot inspection identified homoscedasticity along the regression line, which necessitated estimation of robust standard errors.

**Post-hoc analysis of predictors of time to initiation of therapy services—** Because time to initiation of therapy services was a significant predictor of patient outcomes, we then modeled the association between demographic and clinical factors and time to first therapy consult and time to first treatment with linear regression models. All demographic and clinical factors identified as statistically significant predictors in bivariate analyses were included in a multivariable model that also controlled for age, gender, and stroke subtype, given that these factors have been previously shown to affect receipt of therapy services.[39,40]

All study procedures were approved by the Institutional Review Board for the protection of human subjects, and all data preparation and statistical analyses were carried using STATA/IC 12.1 for Mac.

# Results

Table 1 presents a demographic and clinical summary of the 553 study participants. The average age of the sample was 66.6 years (sd=15.5). Most were white (64.4%), male (51.9%), and presented with ischemic strokes (88.8%) that were mild in nature (median NIHSS: 3; IQR: 0–28). The majority received a therapy consult within 2 days of hospital admission (IQR = 1–3 days), and for those who received a therapy treatment (n=275, 49.7%), most received their first treatment within 4 days of admission (IQR=3–6).

## Effect of time to therapy on patient outcomes

Table 2 presents the effects of time to initiation of therapy services on patient outcomes. In unadjusted analyses, patient disability increased, and self-reported physical and cognitive function decreased at 30 days for each additional day between hospital admission and therapy consult. When controlling for age, stroke severity, stroke type (IS vs. TIA), and stroke subtype (TOAST classification), time to consultation predicted executive function, general cognitive concerns, and BI at 30 days for patients with mild strokes. For those with moderate-severe strokes, time to treatment predicted lower extremity mobility and mRS in adjusted analyses.

### Post-hoc assessment of predictors of time to initiation of therapy services

With respect to time to receipt of therapy consults, statistically significant predictors included TOAST classification, stroke severity, intensive care unit (ICU) and non-ICU length of stay (LOS), comorbid diabetes or atrial fibrillation, and in-hospital pneumonia (Appendix 1). Of these, stroke subtype, diabetes, atrial fibrillation, ICU LOS, and non-ICU LOS remained statistically significant in the multivariable model (Table 3). With respect to time to receipt of therapy treatments, statistically significant predictors included history of stroke, TOAST classification, stroke type (IS vs. TIA), stroke severity, pre-stroke ambulatory status, ICU and non-ICU LOS, in-hospital pneumonia, pulmonary embolism, and deep vein thrombosis. Of these, prior stroke, ischemic stroke type, ICU LOS, and non-ICU LOS remained statistically significant in the multivariable model.

## Discussion

We aimed to assess the effect of time to initiation of therapy consults and treatments on disability and quality of life at 30 days following ischemic stroke and TIA. There are a number of ways in which this study informs the literature on timing of rehabilitation services. First, we validated findings previously assessed with performance measures using PROs. Second, we tested the effect of time to initiation of both therapy consults and treatments (i.e., initiation and follow-up visits). Third, we explored differential effects by stroke severity. Our findings indicate that for patients with ischemic stroke or TIA, longer time to initiation of acute therapy consults and treatments was associated with increased disability and decreased self-reported physical and cognitive function 30-days after stroke. We also noted differential effects between timing of initiation of acute therapy consults and treatments based on stroke severity. For patients with mild strokes, time to acute therapy consults was associated with worse disability (i.e., Barthel's index) and cognitive functioning, whereas time to acute therapy treatments was associated with worse disability (i.e., mRS) and physical function (i.e., lower extremity mobility) only in patients with moderate to severe stroke. On average, a 7-day delay in therapy consults was associated with T-scores reduction of 4 points in general cognition and 6 points in executive function for those with mild strokes, which represents approximately ½ SD expected change. For those with moderate to severe strokes, a 7-day delay in therapy treatments lead to T-score reduction of 4 points in mobility (i.e., ½ SD), as well as significant associations with higher levels of disability. While minimal clinically important differences (MCIDs) in NeuroQOL measures have yet to be formally assessed for patients with TIA and ischemic stroke, these estimates meet or exceed the most commonly observed MCIDs of 1/3 to 1/2 SD for PROs[41–44]. These findings suggest that prompt initiation of acute therapy consults and treatments may have significant impact in stroke recovery that varies by the severity of the stroke.

### Effect of time to therapy on patient outcomes

Our results suggest that longer delays to initiation of therapy services may have negative effects on patients' cognitive and physical functions, but our data were unable to provide evidence for an optimal time point for initiation of acute therapy services. To date, several randomized controlled trials have assessed early initiation of therapy services.[45,46] Each of these studies suggests that therapy services are feasible, safe, and effective for motor recovery after stroke. Yet, the largest multi-institutional randomized controlled trial, which focused on the provision of intense therapy services within 24 hours of stroke onset showed that receipt of therapy at a very early stage, observed increased odds of disability and mortality in the early provision group.[46,47] However, in the AVERT trial, the mean time to initiation of therapy services for the usual care group (i.e., control) was approximately 22 hours, which was within the 24-hour window established for the intervention group. In the present study, no patient received therapy within 24 hours of admission, and the median time to initiation of therapy services (i.e., consult) was 2 days. These findings suggest that earlier (although not necessarily within 24 hours) provision of therapy services could potentially reduce long-term disability after ischemic stroke. Our results more closely resemble those of Tong et al.[45] who validated and expanded on the findings of the AVERT trial, demonstrating that provision of therapy services between 24–48 hours after stroke onset resulted in a higher proportion of patients achieving favorable outcomes compared to those receiving services of the same intensity but within 24 hours of stroke onset. In that study, patients receiving therapy services after 24 hours of stroke onset had the same proportion of favorable outcomes regardless of therapy intensity. Yet, the controversy regarding optimal timing of therapy services after stroke remains unsettled, as both the AVERT trial and Tong et al showed positive outcomes with usual care intensity. Findings from our study also suggest that delaying therapy services beyond 48 hours might be detrimental to patient outcomes, as each day between admission and therapy consult resulted in increased odds of poor outcome at 30 days. Future studies should attempt to identify optimal time frames for initiation of acute therapy services that would lead to the most favorable patient outcomes.

We also assessed the impact of time to initiation of acute therapy using patient reported quality of life. We found (1) that longer time to initiation of acute therapy consults and treatments was associated with decreased self-reported physical and cognitive function 30-days after stroke and (2) a differential effect between timing of initiation of acute therapy consults and treatments based on stroke severity. In detail, patients with mild strokes had worse cognitive function associated with longer times to acute therapy consults, whereas patients with moderate-severe stokes had worse physical function associated with longer time to acute therapy treatments. Our results confirm previous findings that cognitive impairments are a common stroke sequelae; yet, common acute care measures of stroke severity (e.g., NIHSS) do not capture the complexities associated with mild stroke (e.g., cognitive impairment).[18,21,22]

In terms of physical function, our findings are consistent with previous research showing that provision of acute therapy services improves physical function after stroke.[3] Our results are also similar to previous studies that assessed time to initiation of inpatient therapy services using performance measures (e.g. FIM) as outcomes and stroke onset as a predictor.

[48–50] While these studies focusing on inpatient rehabilitation conclude that fewer days from stroke onset to inpatient rehabilitation facility admission might lead to better functional outcomes, we suggest that fewer days to acute rehabilitation while in the hospital may also lead to better functional outcomes. Moreover, our findings indicate that a 7-day delay to initiation of therapy services may have a significant impact to patient quality of life that meets or exceed the most commonly accepted estimates of MCIDs for PROs, irrespective of stroke severity. Taken together, these results suggest that early intervention helps mitigate the impact of stroke on both cognitive and physical domains, but with differential effects based on stroke severity. In order to reduce long-term impairments in physical and cognitive function, improved institutional processes are warranted to ensure early therapy is provided to all eligible stroke patients.

## Predictors of time to initiation of therapy services

While neither presence of medical complications nor stroke severity were related to time to consult, time to consult was shorter for people with ischemic stroke (vs. TIA), diabetes, atrial fibrillation, and with shorter LOS. These factors are similar to those reported in previous studies.[39] Our results suggest that patient characteristics and expected discharge date may affect provision of therapy consults. Although LOS is often unpredictable, it is conceivable that therapists prioritize patients based on expected or approximated discharge date in order to ensure that most patients are assessed for therapy prior to discharge and, thus, in compliance with the Joint Commission Guidelines.

In terms of time to treatment, approximately 50% of patients who received a therapy consult received a therapy treatment in the hospital. The results were similar to time to consult in that neither medical complications nor stroke severity were associated with time to treatment. Also, time to treatment was shorter for patients with no prior stroke, those with a diagnosis of ischemic stroke, and those with shorter LOS. These results were unexpected, given that therapy treatments are focused on recovery of function, and our findings do not suggest that physical function is a significant predictor of time to initiation of therapy treatments. To our knowledge, this is the first study to evaluate predictors of time to initiation of therapy treatments during acute hospitalizations in patients with ischemic stroke or TIA. However, it remains unclear whether some of these patients were discharged before having the opportunity to receive treatment within the hospital. Future studies should expand upon the results presented here and further investigate which patients would benefit from therapy treatments within the hospital prior to hospital discharge.

## Limitations

This study has several important limitations. This study was carried out at a single acute care center in a large metropolitan area, and almost all patient outcome measures were self-report measures of physical and cognitive function. Future studies should include more regionally diverse patient populations and implement additional measures of performance, such as gait speed, arm motor testing, and more detailed batteries of physical and cognitive function (i.e., NIH Toolbox, PROMIS, Neuro-QoL). These additional measures should help disentangle performance differences in recovery from perceived differences in recovery.

## Conclusions

Longer time to initiation of acute therapy has differential effects on post-stroke disability and HRQoL up to 1-month after ischemic stroke and TIA. The effect of time to acute therapy consult is more impactful for those with mild deficits, while the effect of time to acute therapy treatment is more impactful for those with moderate to severe deficits. Minimizing time to therapy consults and treatments in the acute hospital period might improve outcomes after ischemic stroke and TIA.

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## Appendix 1.: Univariate effects of patient characteristics on time to initiation of therapy services

| | Time to Consult | | | | | Time to Treatment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Therapy consult | b | se | t | p | 95% CI-LB | b | se | t | p | 95% CI-LB |
| Age | −0.007 | 0.005 | −1.33 | 0.183 | −0.018−0.003 | −0.012 | 0.011 | −1.07 | 0.286 | −0.033–0.010 |
| Female | 0.175 | 0.214 | 0.82 | 0.412 | −0.245–0.596 | −0.038 | 0.378 | −0.10 | 0.921 | −0.781–0.706 |
| Hispanic | −0.226 | 0.579 | −0.39 | 0.697 | −1.364–0.912 | 0.041 | 0.736 | 0.060 | 0.956 | −1.408–1.490 |
| Race | | | | | | | | | | |
| Caucasian/ White (ref) | | | | | | | | | | |
| African-American/ Black | −0.115 | 0.215 | −0.53 | 0.593 | −0.536–0.307 | 0.240 | 0.400 | 0.60 | 0.550 | −0.548–1.027 |
| Other | 0.440 | 0.722 | 0.61 | 0.543 | −0.978–1.859 | −0.802 | 1.225 | −0.65 | 0.513 | −3.214–1.610 |
| Insurance | | | | | | | | | | |
| Medicare (ref) | | | | | | | | | | |
| Private | 0.065 | 0.237 | 0.29 | 0.773 | −0.398–0.534 | 0.078 | 0.412 | 0.19 | 0.849 | −0.733–0.889 |
| Other | 0.589 | 0.325 | 1.81 | 0.071 | −0.050–1.227 | 0.710 | 0.620 | 1.14 | 0.253 | −0.511–1.930 |
| Risk factors (present vs absent) | | | | | | | | | | |

| | Time to Consult | | | | | Time to Treatment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Therapy consult** | **b** | **se** | **t** | **p** | **95% CI-LB** | **b** | **se** | **t** | **p** | **95% CI-LB** |
| History of smoking | 0.196 | 0.223 | 0.88 | 0.379 | −0.241–0.634 | 0.307 | 0.398 | 0.77 | 0.441 | −0.476–1.090 |
| Current alcohol abuse (>5 drinks/day) | −0.535 | 0.330 | −1.62 | 0.105 | −1.184–0.113 | −0.391 | 0.752 | −0.52 | 0.603 | −1.872–1.090 |
| Prior ischemic stroke | 0.244 | 0.261 | 0.94 | 0.350 | −0.268–0.756 | 0.925 | 0.500 | 1.85 | 0.065 | −0.059–1.908 |
| Prior hemorrhagic stroke | 0.898 | 1.073 | 0.84 | 0.403 | −1.210–3.005 | 3.600 | 2.294 | 1.57 | 0.118 | −0.916–8.115 |
| Prior ischemic or hemorrhagic stroke | 0.334 | 0.263 | 1.27 | 0.205 | −0.183–0.851 | 1.234 | 0.513 | 2.41 | 0.017 | 0.225–2.243 |
| Stroke type | | | | | | | | | | |
| Ischemic (vs. TIA) | −0.038 | 0.332 | −0.11 | 0.909 | −0.689–0.614 | 1.283 | 0.468 | 2.74 | 0.007 | 0.361–2.204 |
| Toast Classification | | | | | | | | | | |
| Cardioembolic/ Large artery (vs. Other) | −0.680 | 0.234 | −2.90 | 0.004 | −1.140–−0.219 | −1.531 | 0.379 | −4.04 | <0.001 | −2.276–−0.785 |
| Stroke severity | | | | | | | | | | |
| NIHSS | 0.089 | 0.032 | 2.75 | 0.006 | 0.025–0.152 | 0.149 | 0.034 | 4.43 | <0.001 | 0.083–0.215 |
| Pre-stroke functional status | | | | | | | | | | |
| mRS (>1 vs 0,1) | 0.007 | 0.347 | 0.02 | 0.984 | −0.675–0.689 | 0.336 | 0.572 | 0.59 | 0.557 | −0.789–1.461 |
| Able to ambulate with or without assistance (vs. unable) | −0.559 | 1.001 | −0.56 | 0.577 | −2.523–1.408 | 0.960 | 0.190 | 5.04 | <0.001 | 0.585–1.335 |
| Comorbidities (present vs absent) | | | | | | | | | | |
| Hypertension | −0.352 | 0.285 | −1.24 | 0.217 | −0.911–0.207 | −0.530 | 0.476 | −1.11 | 0.266 | −1.467–0.407 |
| Diabetes | −0.444 | 0.207 | −2.14 | 0.032 | −0.850–−0.037 | −0.209 | 0.414 | −0.50 | 0.615 | −1.023–0.606 |
| Atrial Fibrillation | −0.481 | 0.206 | −2.34 | 0.020 | −0.885–−0.077 | 0.386 | 0.454 | 0.85 | 0.397 | −0.509–1.280 |
| Coronary Artery Disease | −0.355 | 0.220 | −1.61 | 0.135 | −0.788–0.079 | 0.039 | 0.460 | 0.090 | 0.932 | −0.866–0.945 |
| Complications (present vs absent) | | | | | | | | | | |
| Deep vein thrombosis | 1.668 | 0.978 | 1.71 | 0.088 | −0.252–3.588 | 1.975 | 0.951 | 2.08 | 0.039 | 0.103–3.846 |
| Pulmonary embolism | 0.050 | 0.370 | 0.13 | 0.893 | −0.677–0.777 | −1.960 | 0.190 | −10.33 | <0.001 | −2.333–−1.586 |

| | Time to Consult | | | | | Time to Treatment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Therapy consult** | **b** | **se** | **t** | **p** | **95% CI-LB** | **b** | **se** | **t** | **p** | **95% CI-LB** |
| Pneumonia | 2.062 | 0.985 | 2.09 | 0.037 | 0.124–3.996 | 2.234 | 0.873 | 2.56 | 0.011 | 0.515–3.953 |
| Length of stay | | | | | | | | | | |
| Non-ICU days | 0.211 | 0.050 | 4.20 | <0.001 | 0.112–0.309 | 0.402 | 0.041 | 9.84 | <0.001 | 0.322–0.483 |
| Days in ICU | 0.290 | 0.092 | 3.17 | 0.002 | 0.110–0.470 | 0.360 | 0.066 | 5.42 | <0.001 | 0.229–0.490 |

b=slope, se = Standard Error, CI = Confidence Interval, LB = Lower Bound, UB = Upper Bound, TIA=transient ischemic attack, NIHSS=National Institutes of Health Stroke Scale, mRS=modified Rankin Scale, ICU=intensive care unit

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**Table 1.**

Demographic and clinical profile of participants

| | **Mean** | **(SD)** |
|---|---|---|
| Age in years | 66.6 | (15.5) |
| | **Median** | **[IQR]** |
| Stroke severity (NIHSS) | 3 | [1–6] |
| Days outside ICU | 4 | [2–7] |
| Days inside ICU | 0 | [0–17] |
| | **n=553** | **%** |
| Female | 266 | 48.1 |
| Hispanic (missing 1 participant) | 41 | 7.4 |
| Race | | |
| Caucasian/White | 356 | 64.4 |
| African-American/Black | 175 | 31.7 |
| Other | 22 | 4.0 |
| Insurance | | |
| Medicare | 286 | 51.7 |
| Private | 184 | 33.3 |
| Other | 83 | 15.0 |
| Risk factors | | |
| Ever smoked | 226 | 40.9 |
| Current alcohol abuse (>5 drinks/day) | 14 | 2.5 |
| Prior ischemic stroke | 100 | 18.1 |
| Prior hemorrhagic stroke | 9 | 1.6 |
| Stroke type | | |
| TIA | 62 | 11.2 |
| Ischemic | 491 | 88.8 |
| Toast Classification | | |
| Cardioembolic/Large artery | 225 | 40.7 |
| Other | 328 | 59.3 |
| Functional status | | |
| pre-morbid mRS (missing 8 participants) | | |
| 0–1 | 499 | 90.2 |
| 2–6 | 46 | 8.3 |
| Pre-morbid Ambulation with or without assistance | 544 | 98.4 |
| Comorbidities | | |
| Hypertension | 427 | 77.2 |
| Diabetes | 169 | 30.6 |
| Atrial fibrillation | 79 | 14.3 |
| Coronary artery disease | 113 | 20.4 |
| Complications | | |
| Deep vein thrombosis | 27 | 4.9 |

| | | |
|---|---|---|
| Pulmonary embolism | 2 | 0.4 |
| Pneumonia | 30 | 5.4 |

SD=standard deviation, IQR=interquartile range, NIHSS=National Institutes of Health Stroke Scale, ICU=intensive care unit, TIA=transient ischemic attack, mRS=modified Rankin Scale (≥2 indicate moderate to severe disability

**Table 2.**

Effect of time to initiation of therapy services on patient outcomes at 30 days* (n=540)

| | Time to Consult | | | | | | | | Time to Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 95% CI | | | | | | | | 95% CI | |
| | n | b | OR | SE | t | p | LB | UB | n | b | OR | SE | t | p | LB | UB |
| **Mild Stroke (NIHSS < 5)** | | | | | | | | | | | | | | | | |
| mRS ≥ 2 | 340 | | 1.059 | 0.060 | 1.000 | 0.316 | 0.947 | 1.183 | 144 | | 1.004 | 0.082 | 0.050 | 0.962 | 0.856 | 1.178 |
| BI = 100 (vs <100) | 165 | | 0.818 | 0.062 | −2.640 | 0.008 | 0.704 | 0.950 | 68 | | 1.072 | 0.115 | 0.640 | 0.519 | 0.868 | 1.322 |
| Cognition-Executive Function | 339 | −0.865 | | 0.262 | −3.330 | 0.001 | −1.380 | −0.349 | 144 | −0.066 | | 0.319 | −0.210 | 0.837 | −0.696 | 0.565 |
| Cognition-General Concerns | 340 | −0.609 | | 0.232 | −2.620 | 0.009 | −1.066 | −0.152 | 145 | −0.253 | | 0.294 | −0.860 | 0.391 | −0.834 | 0.328 |
| Physical Function - Upper Extremity | 339 | −0.028 | | 0.229 | −0.120 | 0.904 | −0.479 | 0.423 | 144 | −0.277 | | 0.278 | −1.000 | 0.320 | −0.827 | 0.272 |
| Physical Function - Lower Extremity | 339 | −0.321 | | 0.208 | −1.540 | 0.124 | −0.731 | 0.088 | 144 | −0.168 | | 0.308 | −0.550 | 0.585 | −0.776 | 0.440 |
| **Moderate/Severe Stroke (NIHSS ≥ 5)** | | | | | | | | | | | | | | | | |
| modified Rankin Scale ≥ 2 | 200 | | 1.007 | 0.060 | 0.120 | 0.903 | 0.896 | 1.132 | 124 | | 1.151 | 0.079 | 2.060 | 0.039 | 1.007 | 1.316 |
| Barthel's Index = 100 (vs <100) | 97 | | 0.974 | 0.087 | −0.300 | 0.765 | 0.817 | 1.160 | 68 | | 0.903 | 0.077 | −1.190 | 0.234 | 0.764 | 1.068 |
| Cognition-Executive Function | 200 | −0.277 | | 0.391 | −0.710 | 0.479 | −1.049 | 0.494 | 124 | −0.620 | | 0.424 | −1.460 | 0.146 | −1.460 | 0.220 |
| Cognition-General Concerns | 200 | −0.174 | | 0.230 | −0.760 | 0.450 | −0.627 | 0.279 | 124 | −0.474 | | 0.298 | −1.590 | 0.115 | −1.064 | 0.116 |
| Physical Function - Upper Extremity | 200 | 0.020 | | 0.270 | 0.070 | 0.941 | −0.512 | 0.552 | 124 | −0.349 | | 0.342 | −1.020 | 0.310 | −1.027 | 0.329 |
| Physical Function - Lower Extremity | 200 | −0.170 | | 0.299 | −0.570 | 0.569 | −0.759 | 0.419 | 124 | −0.591 | | 0.293 | −2.020 | 0.046 | −1.171 | −0.011 |

b=slope, OR = Odds Ratio, SE = Standard Error, CI = Confidence Interval, LB = Lower Bound, UB = Upper Bound, mRS=modified Rankin Scale (≥2 indicate moderate to severe disability), BI=Barthel's Index (<100 indicates dependency, 100 indicates independence), NIHSS=National Institutes of Health Stroke Scale

* all models control for age, stroke severity, stroke subtype (TOAST classification), and stroke type (IS vs. TIA)

**Table 3.**

Multivariate effects of patient characteristics on time to initiation of therapy services

| Patient characteristic | Time to Consult (n=553) | | | | | | Time to Treatment (n=275) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% CI | | | | | | 95% CI | |
| | b | se | t | p | LB | UB | b | se | t | p | LB | UB |
| Age | −0.007 | 0.006 | −1.27 | 0.204 | −0.018 | 0.004 | −0.010 | 0.009 | −1.10 | 0.274 | −0.273 | 0.008 |
| Female | 0.182 | 0.188 | 0.97 | 0.334 | −0.187 | 0.550 | 0.283 | 0.274 | 1.03 | 0.303 | −0.257 | 0.822 |
| Risk factors (present vs absent) | | | | | | | | | | | | |
| Prior ischemic or hemorrhagic stroke | | | | | | | 0.824 | 0.325 | 2.54 | 0.012 | 0.185 | 1.465 |
| Stroke type | | | | | | | | | | | | |
| Ischemic (vs. TIA) | −0.762 | 0.264 | −2.88 | 0.004 | −1.281 | −0.243 | −0.643 | 0.285 | −2.26 | 0.025 | −1.203 | −0.082 |
| Toast Classification | | | | | | | | | | | | |
| Cardioembolic/Large artery (vs. other) | −0.398 | 0.218 | −1.82 | 0.069 | −0.826 | 0.031 | −0.518 | 0.294 | −1.76 | 0.079 | −1.096 | 0.599 |
| Stroke severity | | | | | | | | | | | | |
| NIHSS | −0.004 | 0.026 | −0.16 | 0.870 | −0.056 | 0.048 | 0.043 | 0.028 | 1.50 | 0.134 | −0.013 | 0.098 |
| Pre-stroke functional status | | | | | | | | | | | | |
| Able to ambulate with or without assistance (vs. unable) | | | | | | | 0.908 | 0.584 | 1.56 | 0.121 | −0.242 | 2.057 |
| Comorbidities (present vs absent) | | | | | | | | | | | | |
| Diabetes | −0.502 | 0.199 | −2.53 | 0.012 | −0.892 | −0.112 | | | | | | |
| Atrial Fibrillation | −0.945 | 0.282 | −3.35 | 0.001 | −1.499 | −0.392 | | | | | | |
| Complications (present vs absent) | | | | | | | | | | | | |
| Deep vein thrombosis | | | | | | | −0.740 | 0.866 | −0.85 | 0.394 | −2.445 | 0.965 |
| Pulmonary embolism | | | | | | | 0.348 | 0.244 | 1.43 | 0.154 | −0.132 | 0.829 |
| Pneumonia | 0.504 | 0.828 | 0.61 | 0.543 | −1.123 | 2.130 | −0.030 | 0.702 | −0.04 | 0.966 | −1.412 | 1.352 |
| Length of stay | | | | | | | | | | | | |
| Non-ICU days | 0.231 | 0.047 | 4.96 | <0.001 | 0.140 | 0.323 | 0.396 | 0.042 | 9.51 | <0.001 | 0.314 | 0.478 |
| Days in ICU | 0.295 | 0.102 | 2.89 | 0.004 | 0.094 | 0.495 | 0.391 | 0.070 | 5.62 | <0.001 | 0.254 | 0.529 |

b=slope, se = Standard Error, CI = Confidence Interval, LB = Lower Bound, UB = Upper Bound, TIA=transient ischemic attack, NIHSS=National Institutes of Health Stroke Scale, ICU=intensive care unit, mRS=modified Rankin Scale (≥2 indicate moderate to severe disability)